Integrated Vehicle Health Management

Vehicle Maturation/ New Product

Design Engineering Manufacturing
- Production, certification & testing
- Total ownership costs
- System & life cycle
- Requirements
- FMECAs
- Design models
- Failure modes/models
- System test data

Operational Control
- Operational Schedule
- Operational Effectiveness

Maintenance & Logistics
- Operational Demand
- Fleet Availability
- MR & O leading
- Maintenance Scheduling
- Spares Supply
- Asset Tracking
- Maintenance Execution

Acquire
Health Status
- Current
- Predicted

Act

Sense

Transfer
Data Repository & Ground Processing

Analyse

Operational Effectiveness

Operational Demand
The World of Civil Aerospace *

* SAE book, due out later in 2018
Talk Outline

- Battle for the MRO space
- Maintenance Credits
- Autonomy, technology speed
- EU 261
Lufthansa Technik Chairman Seeks Other Stakeholders For Digital Platform

Lufthansa Technik, the biggest MRO in the world, openly invites competitors to join forces in its digital platform to fight potential OEM monopolies.

Lee Ann Shay | Sep 26, 2018
Delta’s Atlanta MRO Engine Facility
Delta’s Atlanta MRO Facility
Talk Outline

- Battle for the MRO space
- Maintenance Credits
- Autonomy, technology speed
- EU 261
Civil Aerospace Engagement


Civil Aircraft Technology Enabled Services – an industry co-operation day, RAeS, London, Nov 2013


IVHM and Maintenance Credits Workshop, Joint SAE/Cranfield/RAeS Cranfield, April 2015

Workshop with Operators/MROs, Joint SAE/Cranfield/RAeS, FIA2016, July 2016

Achieving Maintenance Credits

Tuesday 12 July 2016, 08:00 to 12:00

Aim: Obtain Operator/MRO engagement and input into on-going process to develop standards in the following areas:

a) Collaborating with Regulators
b) Recommended Practices for Maintenance Credits Processes
c) Recommended Practice for Data Interoperability

Agenda:

Welcome
Keynote Speaker (TBC)
Facilitated breakfast sessions to obtain feedback on evolving standards documents
Panel Discussion
Working meetings
SAE - Maintenance Credits

Aerospace Recommended Practice

Aerospace Propulsion Health Management Systems for Maintenance Credit

Rationale

This document has been written to provide a process to achieve Maintenance Credits using Aerospace Propulsion Health Management Systems in a consistent way. This will help Regulators carry out assessments of the merits of a Maintenance Credit application with a view to provide approval.

This document reflects the fact that regulatory approval has been provided to multiple engine and aircraft Original Equipment Manufacturers (OEMs), allowing the use of Propulsion Health Management functionality in the mitigation of Airworthiness Directives, extending inspection intervals, compliance with Maintenance Steering Group-3 (MSG-3) and more effective utilization of component lives to increase "time on wing".

Table of Contents

1. Scope .......................................................................................................................... 1
2. References .................................................................................................................. 2
   2.1 Applicable Documents .......................................................................................... 2
       2.1.1 SAE Publications ......................................................................................... 2
       2.1.2 Related Publications .................................................................................... 2
       2.1.3 Definitions .................................................................................................... 3
       2.1.4 Glossary ........................................................................................................ 3
3. Introduction .................................................................................................................. 4
4. Maintenance & Design Credits .................................................................................. 4
   4.1 Maintenance Credits Process Steps ........................................................................ 5
   Figure 1: Maintenance Credits Process Steps ............................................................. 6
   Appendix A - Maintenance Credit Checklist ................................................................ 8
   Table 1: Maintenance Credit Checklist ......................................................................... 8
   Appendix B - Maintenance Credit Examples ................................................................ 10
   Appendix B1 - Example 1 ............................................................................................ 10
SAE - Regulators and Data

Rationale, Considerations and Framework for Data Interoperability for Health Management within the Aerospace Ecosystem

**Scope**

This AIR establishes a collection of regulations, policy, and guidance applicable to design approval applicants, aircraft operating certificate holders, and maintenance repair and overhaul (MRO) organizations enabling adoption of IVHM technology for use in aircraft maintenance. One of the AIR's objectives is to set the foundation for aircraft operating certificate holders to engage with regulators to not only share 

**Table of Contents**

1. **Scope**
   - Purpose
   - Applicable Documents
   - Abbreviations and Definitions
   - Introduction
   - Technology Creating Big Data in the Aerospace Ecosystem
   - Business Outcomes for Data Interoperability
   - Health Ready Components Driven by IVHM Data Interoperability
   - Cautionary Tale
   - Business Value, Trust, and Risk
   - Intra-Enterprise "Live on an Island"
   - Traditional Bilateral

**Rationale**

Current aerospace systems are generating large amounts of data. For the most part, all this data is being created by siloed entities (i.e., stakeholders like components/subsystem manufacturers, Original Equipment Manufacturers (OEMs), operators) and ends up living within the four walls of these individual entities. Aerospace industry can greatly benefit from turning this data into useful information to support the business goals. To achieve this goal, the industry can benefit from sharing their sanitized data for developing new capabilities that benefit the industry as a whole. Hence, there is a need for a more effective and transparent way to share this data while strictly controlling the proprietary nature of the data adhering to all contractual terms and conditions. The purpose of this document is to describe the current digital data landscape and approach that can support health management.
Bill Heliker and Marcus Labay, FAA, attended SAE’s IVHM Fall 2018 meeting – to learn more about IVHM
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**SURFACE VEHICLE/AEROSPACE RECOMMENDED PRACTICE**

<table>
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<th>JA6268™</th>
<th>PropDft Dec2017</th>
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<tr>
<td>Issued</td>
<td>Proposed Draft</td>
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<td>2017-12-20</td>
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**Design & Run-Time Information Exchange for Health-Ready Components**

**RATIONALE**

This Surface Vehicle & Aerospace Recommended Practice was created to help reduce existing barriers to the successful implementation of Integrated Vehicle Health Management (IVHM) technology into the aerospace and automotive sectors by introducing health-ready components. Health-ready components are augmented either to monitor and report their own health or, alternatively, ones where the supplier provides the integrator sufficient information to accurately assess the component’s health via a higher-level system on the vehicle. The principal motivation for health-ready components is to facilitate enhanced IVHM functionality in supplier-provided components that better meet the needs of end users and government regulators in a cost-effective manner. Underlying this motivation is the assumption that market forces will drive the need to achieve IVHM’s benefits, which will in turn drive new requirements that suppliers must ultimately meet. This recommended practice has two primary objectives: (1) to encourage the introduction of a much greater degree of IVHM functionality in future vehicles at a much lower cost, and (2) to address legitimate intellectual property concerns by providing recommended IVHM design-time and run-time data specification and information exchange alternatives in an effort to help unlock the potential of IVHM.
Health Ready Components—Unlocking the Potential of IVHM

System Integration Process (Integrator)

Supplier Provided Interfaces and Data
Supplier Provided Interfaces and Data
Supplier Provided Interfaces and Data

Asset Level Reference Model (Integration and Update)

IVHM Run Time Capability (Integration and Update)

Component to Asset Interactions (Run-Time)

On Platform, Ground Support or Enterprise IVHM Functions

User Interactions (Run Time)
Talk Outline

- Battle for the MRO space
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### SAE’s Automated Driving Levels

<table>
<thead>
<tr>
<th>SAE level</th>
<th>Name</th>
<th>Narrative Definition</th>
<th>Execution of Steering and Acceleration/Deceleration</th>
<th>Monitoring of Driving Environment</th>
<th>Fallback Performance of Dynamic Driving Task</th>
<th>System Capability (Driving Modes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Automation</td>
<td>the full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Human driver</td>
<td>n/a</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>the driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>Human driver and system</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>2</td>
<td>Partial Automation</td>
<td>the driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task</td>
<td>System</td>
<td>Human driver</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Automated driving system (“system”) monitors the driving environment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Conditional Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task with the expectation that the human driver will respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>Human driver</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>4</td>
<td>High Automation</td>
<td>the driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>Some driving modes</td>
</tr>
<tr>
<td>5</td>
<td>Full Automation</td>
<td>the full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver</td>
<td>System</td>
<td>System</td>
<td>System</td>
<td>All driving modes</td>
</tr>
</tbody>
</table>
Waymo and Driverless Cars
Waymo and Driverless Cars

Insurance via Trov:


The cost being trip based, but not passed on to the rider:

https://www.theverge.com/2017/12/19/16796370/waymo-trov-self-driving-car-insurance

Washington allows autonomous cars as ‘strict regulation would do more harm than good’:

Talk Outline

- Battle for the MRO space
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- EU 261
• Under EU Regulation 261/2004, passengers are entitled to up to £460 in compensation when their flight lands at their destination more than three hours

• In September 2015, the Court of Justice of the European Union judged, regarding Case C-257/14:[16]
  
  ➢ Even in the event of a flight cancellation on account of unforeseen technical problems, air carriers are required to compensate passengers.
  
  ➢ However, certain technical problems resulting, in particular, from hidden manufacturing defects affecting the safety of flights or acts of sabotage or terrorism may exempt air carriers from their obligation to pay compensation.


Conclusion

• IVHM is maturing and support in maintenance practises, maintenance credits, autonomy and legislation demonstrates it

• More yet to come, in: health ready components, safety, certification and design

• In all case IVHM is a key enabler of the way forward
Embraer - AHEAD

Traditional Unscheduled Maintenance Action

Maintenance with Fault Forwarding (AHEAD)

Prognostics

Scheduled Maintenance

On gate

Next Flight

Fault Report
Diagnostics
Maint. Planning
Maint. Action

Turn-around-time optimization

Perform maintenance action at most convenient time

No surprises!